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Evaluation of Periodontal Problems in Lingual Orthodontia: A Clinical Study

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Abstract **Objectives:** Lingual orthodontics offers esthetic advantages by placing brackets on the inner surfaces of teeth. However, the impact of lingual appliances on periodontal health remains under-explored. **Aim:** To evaluate periodontal changes in patients undergoing lingual orthodontic therapy over a 6-month period. **Methods:** A prospective observational study was conducted on 60 systemically healthy participants (aged 18-35 years) receiving fixed lingual appliances. Periodontal parameters including Plaque Index (PI), Gingival Index (GI), Bleeding on Probing (BOP), Probing Pocket Depth (PPD) and Clinical Attachment Level (CAL) were assessed at baseline (T0), 3 months (T1) and 6 months (T2). Statistical analysis was performed using repeated measures ANOVA. **Results:** Significant increases in mean PI (T0: 0.68 to T2: 1.52) and GI (T0: 0.62 to T2: 1.48) were observed ($p<0.001$). BOP increased from 12.5% to 41.9%. Mean PPD and CAL also increased significantly over time ($p<0.001$), though within mild clinical thresholds. The most pronounced changes occurred in posterior lingual regions. **Conclusion:** Lingual orthodontic appliances are associated with a progressive decline in periodontal health, particularly due to plaque retention and hygiene challenges. Close monitoring and patient education are critical to prevent long-term periodontal complications during lingual therapy. These findings highlight the need for tailored oral hygiene protocols and close interdisciplinary monitoring during lingual orthodontic therapy to minimize long-term periodontal risks.

Key Words Lingual Orthodontics, Periodontal Health, Plaque Index, Gingival Inflammation, Orthodontic Appliances

INTRODUCTION

Orthodontic treatment is widely recognized for its ability to correct malocclusions and enhance esthetics, function and long-term dental health. While conventional labial orthodontics remains the mainstream modality, lingual orthodontics has emerged as a popular alternative due to its superior esthetic advantages. In lingual orthodontia, brackets and wires are placed on the palatal or lingual surfaces of the teeth, rendering them virtually invisible. This modality is particularly appealing to adult patients and professionals who prefer discretion during orthodontic therapy. However, despite its cosmetic benefits, lingual orthodontia presents unique biomechanical and clinical challenges, especially in relation to periodontal health [1].

The proximity of lingual appliances to the gingival margin and the tongue alters the local oral environment significantly. It interferes with natural cleaning mechanisms, complicates oral hygiene maintenance and may affect plaque accumulation patterns differently than labial systems. This alteration in plaque dynamics potentially exacerbates the risk of periodontal inflammation, including gingivitis, Bleeding on Probing (BOP), increased probing pocket depths (PPD) and attachment loss [2,3]. Moreover, the smaller inter-bracket distance and complex wire mechanics often used in lingual systems may cause torque control issues, further contributing to localized periodontal stresses [4].

Clinical evidence suggests that patients undergoing lingual orthodontic treatment are more prone to gingival

inflammation and mucosal irritation, particularly in the posterior segments. These effects are often aggravated in patients with pre-existing periodontal conditions or poor compliance with oral hygiene protocols [5]. The difficulty in accessing the lingual surfaces for routine brushing and flossing amplifies these risks. Unlike labial appliances, lingual brackets are often in closer proximity to soft tissue structures such as the tongue and palatal mucosa, which can become traumatized and contribute to secondary inflammation and discomfort [6].

In addition to clinical presentation, the microbial environment in lingual orthodontics has been shown to differ from that in labial systems. Studies report higher levels of anaerobic pathogens and changes in subgingival microbiota composition, which are associated with early periodontal tissue breakdown if not adequately managed [7]. Furthermore, salivary flow, pH changes and food retention patterns differ in patients with lingual appliances, creating a complex interplay between host response and appliance-induced stress [8].

Although lingual orthodontics has seen advancements in appliance design and customization, including CAD/CAM technologies and digital bracket positioning, there remains a relative paucity of research exploring its impact on periodontal parameters in clinical settings. Most existing data are limited to case reports or short-term studies, with heterogeneous populations and inconsistent periodontal indices [9]. However, many of these studies suffer from methodological limitations such as small sample sizes, non-standardized periodontal indices and short observation periods and they also report conflicting outcomes-some indicating only transient gingival changes while others suggest progressive periodontal deterioration-thereby underscoring the need for more robust and long-term clinical evidence. This gap underlines the need for well-structured clinical investigations that objectively assess periodontal outcomes in lingual orthodontic patients.

Given these considerations, this study was designed to evaluate the prevalence and severity of periodontal problems encountered during lingual orthodontic treatment. Through a systematic clinical assessment of gingival inflammation, plaque indices, probing depths and attachment levels over the course of treatment, this study aims to quantify the periodontal implications of lingual appliance therapy in a real-world population. By doing so, it may offer valuable insights into risk stratification, preventive strategies and patient education, ultimately improving the safety and efficacy of lingual orthodontics [10].

METHODS

Study Design and Setting: This was a prospective, observational clinical study conducted at the Department of Orthodontics and Periodontics in a tertiary dental teaching hospital. Ethical clearance was obtained and consents were also taken from the subjects.

Study Population

A total of 60 participants, aged between 18 to 35 years, undergoing fixed orthodontic treatment using lingual appliances were recruited between March 2023 and October 2023. Patients were selected based on consecutive sampling from the outpatient orthodontic clinic. Randomized sampling in future research would help improve generalizability.

Inclusion Criteria

- Patients with mild to moderate malocclusion indicated for lingual orthodontic therapy
- Systemically healthy individuals
- Periodontally healthy at baseline (no clinical attachment loss, PPD <3 mm, no radiographic bone loss)
- Minimum treatment duration expected ≥6 months

Exclusion Criteria

- Smokers and tobacco users
- Pregnant or lactating women
- Patients with history of periodontal therapy within the last 6 months
- Individuals on long-term antibiotic or anti-inflammatory therapy
- Patients with systemic diseases affecting periodontium (e.g., diabetes, autoimmune disorders)

Orthodontic Intervention

All patients received a customized lingual orthodontic appliance system with indirect bonding technique. Archwire sequences and torque mechanics were standardized across the sample. Oral hygiene instructions were given at the start of treatment and reinforced at each monthly follow-up.

Periodontal Assessment

Periodontal evaluation was carried out at three time-points:

- T0 (Baseline-before appliance placement)
- T1 (3 months post-placement)
- T2 (6 months post-placement)

The following clinical parameters were recorded:

- **Plaque Index (PI):** Silness and Löe method
- **Gingival Index (GI):** Löe and Silness criteria
- **Bleeding on Probing (BOP):** Presence/absence within 15 seconds
- **Probing Pocket Depth (PPD):** Measured at six sites per tooth using UNC-15 probe
- **Clinical Attachment Level (CAL):** From CEJ to base of sulcus

Although only clinical indices were assessed in this study, the inclusion of microbiological or radiographic evaluations could have provided deeper insight into the underlying periodontal changes. All assessments were performed by a calibrated periodontist (intra-examiner reliability kappa = 0.92).

Calibration and Reliability

A pilot assessment was conducted on 10 non-study participants to establish intra-examiner reliability. Calibration was repeated at 3-month intervals to maintain consistency.

Data Collection and Recording

Data were recorded in structured pro forma sheets and later transcribed into digital format. Clinical photographs and radiographs were also obtained for documentation.

Statistical Analysis

Statistical analysis was conducted using IBM SPSS version 25. Descriptive statistics were calculated as means ± standard deviations for continuous variables and percentages for categorical variables. Repeated measures ANOVA was used to compare periodontal parameters across the three time-points. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 60 participants (34 females, 26 males) with a mean age of 24.8±4.3 years completed the study. Periodontal parameters were evaluated at three time-points: Baseline (T0), 3 months (T1) and 6 months (T2). The following are the findings for each clinical variable.

Plaque Index (PI) Scores Increased Significantly Over Time

The mean Plaque Index increased from baseline to 6 months, with statistically significant differences observed between T0 and T1 and between T1 and T2. This suggests that plaque accumulation worsened as the duration of lingual orthodontic appliance use increased Table 1 and Figure 1.

Gingival Index (GI) Values Also Showed Progressive Inflammation

Gingival Index scores increased steadily from T0 to T2, reflecting the development of gingival inflammation associated with prolonged appliance wear and poor access for oral hygiene maintenance Table 2 and Figure 2.

Bleeding on Probing (BOP) Significantly Increased by 6 Months

There was a notable rise in the percentage of sites showing bleeding on probing over the 6- month follow-up. The increase from T0 to T1 and further to T2 was statistically significant, indicating worsening gingival health Table 3 and Figure 3.

Probing Pocket Depth (PPD) and CAL Showed Mild but Statistically Significant Changes

Although the average increase in PPD and CAL was within mild clinical thresholds, the progression over time was statistically significant. Most increases were noted in posterior lingual segments Table 4 and Figures 4,5.

Summary of Key Findings:

- **PI and GI Scores:** Significantly increased over time, indicating progressive plaque retention and gingival inflammation
- **BOP:** Rose from 12.5% at baseline to 41.9% at 6 months
- **PPD and CAL:** Showed a trend toward early attachment loss, particularly in posterior regions

Table 1: Mean Plaque Index (PI) Scores over Time

Time Point	Mean PI ± SD	p-value (vs previous)
T0	0.68±0.21	–
T1	1.21±0.33	<0.001
T2	1.52±0.37	<0.001

Table 2: Mean Gingival Index (GI) Scores over Time

Time Point	Mean GI ± SD	p-value (vs previous)
T0	0.62±0.25	–
T1	1.15±0.29	<0.001
T2	1.48±0.34	<0.001

Table 3: Bleeding on Probing (BOP)-Percentage of Sites Affected

Time point	Mean % Sites with BOP±SD	p-value (vs previous)
T0	12.5±6.2%	–
T1	28.3±8.4%	<0.001
T2	41.9±10.1%	<0.001

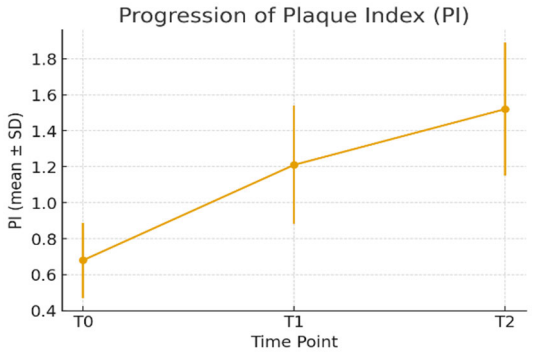

Figure 1: Progression of PI

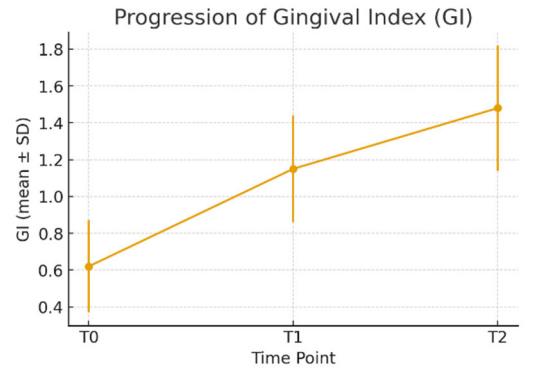

Figure 2: Progression of GI

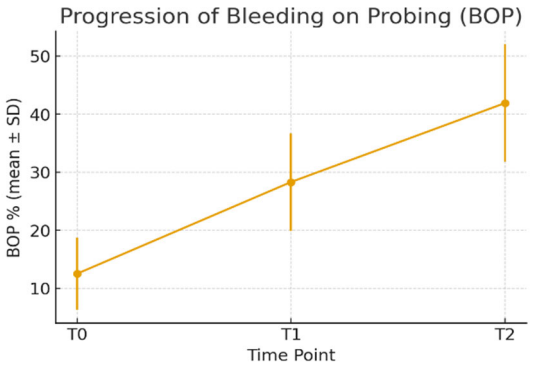

Figure 3: Progression of BOP

Table 4: Mean Probing Pocket Depth (PPD) and Clinical Attachment Level (CAL)

Parameter	T0 (mm)	T1 (mm)	T2 (mm)	p-value
PPD	2.32±0.41	2.68±0.48	2.91±0.52	<0.001
CAL	2.42±0.39	2.74±0.44	2.98±0.49	<0.001

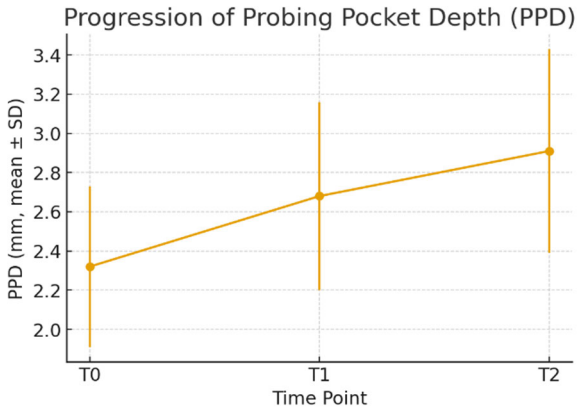

Figure 4: Progression of PPD

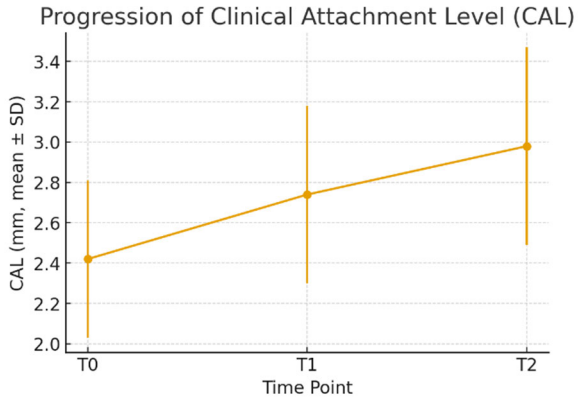

Figure 5: Progression of CAL

DISCUSSION

The present clinical study investigated the progression of periodontal changes in patients undergoing lingual orthodontic therapy over a period of six months. The results demonstrated statistically significant increases in plaque accumulation, gingival inflammation, bleeding on probing and mild attachment loss over time. These findings underscore the potential periodontal risks associated with lingual appliance systems, particularly when meticulous oral hygiene is not maintained.

The observed increase in Plaque Index (PI) from baseline to 6 months aligns with the established challenge of cleaning the lingual surfaces, especially in posterior teeth. The design and positioning of lingual brackets impede proper brushing and flossing, often resulting in stagnation zones that promote plaque retention [11]. Unlike labial appliances, lingual brackets create niches that are less accessible to conventional cleaning methods, even when patients are highly motivated. Furthermore, the close proximity of the appliance to the gingival margin and tongue contributes to mechanical irritation and encourages microbial colonization [12].

The consistent rise in Gingival Index (GI) mirrors the trajectory of plaque accumulation. Gingival inflammation, as evidenced by increasing GI scores, is a well-documented response to persistent biofilm exposure. In the lingual system, the mucosal tissues are more delicate and often subjected to repeated irritation from appliance components, which further exacerbates inflammatory responses [13]. Previous studies have highlighted that the palatal and lingual gingiva exhibit increased susceptibility to inflammation due to thinner keratinized mucosa and reduced salivary cleansing in these regions [14].

Bleeding on Probing (BOP) is a sensitive clinical marker for gingival inflammation and vascular changes in response to microbial challenge. The progressive increase in BOP percentage observed in our study-from 12.5% at baseline to 41.9% at six months-reflects the inflammatory burden carried by patients with lingual appliances. These values are notably higher than those reported in labial orthodontic patients over similar durations, reinforcing the need for targeted hygiene education and frequent professional monitoring [15].

The mild but statistically significant rise in Probing Pocket Depth (PPD) and Clinical Attachment Level (CAL) suggests the initiation of early periodontal breakdown in some cases. Although the mean PPD remained below 3 mm, a shift of even 0.5 mm is clinically relevant, especially in young adults who were periodontally healthy at baseline. Studies have reported similar outcomes, attributing such changes to microbial shifts in the subgingival environment, dominated by anaerobic and pathogenic species during orthodontic treatment [16]. The altered ecological balance within plaque biofilms, favored by the retention sites of lingual brackets, can lead to qualitative changes in microbial virulence, increasing the risk for periodontal tissue damage [17].

Another notable finding of this study is that the most pronounced changes in all parameters were observed in posterior segments, particularly the molar and premolar regions. These teeth are more difficult to access for both mechanical cleaning and professional instrumentation in the presence of lingual appliances. Additionally, the force application and torque control mechanisms in lingual therapy often differ in these areas, leading to greater soft tissue stress [18].

From a biological perspective, the continuous mechanical loading of the periodontium during tooth movement can modulate local inflammatory pathways and cytokine expression. However, in the presence of plaque-induced inflammation, these effects may become deleterious rather than reparative. Orthodontically induced inflammatory root resorption and alveolar bone remodeling have also been found to be influenced by oral hygiene status and appliance design [19].

Despite the concerning trends, it is important to note that none of the patients in this study developed severe periodontitis or required interruption of orthodontic treatment due to periodontal complications. This indicates that while lingual appliances pose added challenges, timely intervention and supportive care can mitigate long-term risks. The integration of customized hygiene protocols-such as the use of interdental brushes, water flossers and

antimicrobial rinses-should be considered a standard of care for lingual orthodontic patients [20-24].

Our findings support the need for frequent periodontal evaluation, particularly during the first 6 months of treatment. They also emphasize the role of patient education, clinician training and appliance design in minimizing iatrogenic periodontal damage during lingual orthodontic therapy.

CONCLUSION

Lingual orthodontic therapy, while offering superior esthetics, is associated with a measurable increase in periodontal inflammation and early attachment loss, particularly in posterior segments. Regular monitoring, patient education and the incorporation of enhance oral hygiene strategies are essential to minimize these risks. The study emphasizes the need for interdisciplinary collaboration between orthodontists and periodontists to ensure optimal treatment outcomes and long-term periodontal health in patients opting for lingual appliances.

Limitations and Recommendations

The study was limited by its single-center design and relatively short observation period. A longer follow-up is necessary to determine whether the early periodontal changes observed stabilize, worsen, or reverse after appliance removal. Additionally, microbial analysis and radiographic assessments would provide more insights into the pathophysiology underlying the observed clinical outcomes. Future studies should incorporate effect size and confidence interval reporting to provide a more robust understanding of clinical significance. Future research should also compare outcomes between lingual and labial systems in matched cohorts to draw more definitive conclusions.

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